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COMMITTEE OF EXPERTS ON THE TRANSPORT
OF DANGEROUS GOODS

REPORT OF THE COMMITTEE OF EXPERTS ON ITS SEVENTEENTH SESSION

(7-16 December 1992)

Addendum 6

Annex 7: Amendments to the Recommendations on the Transport of Dangerous Goods, Tests and Criteria (including new tests and criteria for lithium batteries). (Refer to document ST/SG/AC.10/11/Rev.1)

AMENDMENTS TO THE RECOMMENDATIONS ON THE TRANSPORT OF DANGEROUS GOODS, TESTS AND CRITERIA, (Document ST/SG/AC.10/11/Rev.1)

PART IV

Add the following new Section 2:

"2 TEST METHODS FOR LITHIUM CELLS AND BATTERIES

2.1 PURPOSE

This section presents the procedures to be followed for the classification of lithium cells and batteries (see UN 3090 and UN 3091, and Special Provisions 188 and 230 in Chapter 3 of the Recommendations on the Transport of Dangerous Goods).

2.2 GENERAL

2.2.1 Lithium cells and batteries should be subjected to the classification procedures, as applicable, under Special Provisions 188 and 230 prior to the initial transport of a particular cell or battery type. Lithium cells or batteries which differ from a tested type by:

(a) a change of more than 20% by mass to the cathode, to the anode, or to the electrolyte; or

(b) a change that would materially affect the test results

should be considered a new type and should be subjected to these classification procedures. In the event that a lithium cell or battery type does not meet the test criteria in 2.4, steps should be taken to correct the deficiency or deficiencies that caused the failure before such cell or battery type is retested.

2.2.2 For the purposes of this section:

Battery means two or more cells which are electrically connected together by a permanent means;

Cell means a single encased electrochemical unit which exhibits a voltage differential across its two terminals;

Component cell means a cell contained in a battery;

Cycle means one sequence of fully charging and fully discharging a rechargeable cell or battery;

Disassembly means a vent or rupture where solid matter from any part of a cell or battery penetrates a wire mesh screen (annealed aluminium wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell or battery;

Effluent means a liquid or gas released when a cell or battery vents or leaks;

First cycle means the initial cycle following completion of all manufacturing processes;

Fully charged means a rechargeable cell or battery which has been electrically charged to its designed starting condition;

Fully discharged means either:

(a) a primary cell or battery which has been electrically discharged to remove 100% of its rated capacity; or

(b) a rechargeable cell or battery which has been electrically discharged to a load voltage of less than 2/3 of its starting open circuit voltage;

Primary means a cell or battery which is not designed to be electrically charged or recharged;

Protective devices means devices such as fuses, diodes and current limiters which stop the current flow, block the current flow in one direction or limit the current flow in an electrical circuit;

Rated capacity means the capacity, in ampere-hours, of a cell or battery as measured by subjecting it to a load, temperature and voltage cutoff point specified by the manufacturer;

Rechargeable means a cell or battery which is designed to be electrically recharged;

Short circuit means a direct connection between positive and negative terminals of a cell or battery that provides a virtual zero resistance path for current flow;

Type means a particular electrochemical system and physical design of cells or batteries;

Undischarged means a primary cell or battery which has not been discharged; such a discharge does not include normal self-discharge resulting from reactions during storage.

2.2.3 Under this classification procedure lithium cells and batteries are subjected to a number of test series simulating extreme conditions of transport. Each test series includes one or more test procedures. These test procedures include:

2.2.3.1 altitude simulation: Cells and batteries are stored for at least 6 hours at an absolute pressure of 11.6 kPa and a temperature of 20°C;

2.2.3.2 extreme temperature exposure: Cells and batteries are stored for at least 48 hours at a temperature of 75°C, followed immediately by storage for at least 6 hours at a temperature of -20°C, followed immediately by storage for at least 24 hours at room temperature. The maximum time between storage at 75°C and -20°C is 5 minutes;

2.2.3.3 short circuit: At a test temperature of 55°C, cells and batteries are subjected to a short circuit current by connecting a conductor across the positive and negative terminals. Cells and batteries should remain connected to the conductor for at least 1 hour after the case temperature has returned to 55°C;

2.2.3.4 vibration: Cells and batteries are rigidly clamped to the platform of the vibration machine in such a manner that they are firmly held without any dimensions being altered. A simple harmonic motion having an amplitude of 0.8 mm (1.6 mm total excursion) is applied. The frequency is varied at a rate of 1 Hz/min between the limits of 10 to 55 Hz. The entire range of frequencies and return is traversed in 95±5 minutes for each of three mutually perpendicular mounting positions of the cell or battery. Where a cell or battery has only two axes of symmetry, it is tested perpendicular to each axis. One of the directions of vibration is perpendicular to the terminal face;

2.2.3.5 shock: Cells and batteries are secured to the shock test apparatus by means of a rigid mount which will support all mounting surfaces. Each cell and battery is subjected to three shocks of equal magnitude applied in each of three mutually perpendicular directions normal to the face of the cell or battery. In each case, the cell or battery is accelerated in such a manner that during the first 3 milliseconds the minimum average acceleration is 75 times the local acceleration due to gravity. The peak acceleration should be between 125 and 175 times the local acceleration due to gravity;

2.2.3.6 charge test: A test cell or battery is connected in a series string with undischarged primary cells or batteries or fully charged rechargeable cells or batteries of the same type in such a way that the terminals of the test cell or battery are connected in reverse. For cells with nominal voltages of less than

2 volts and batteries containing component cells with nominal voltages of less than 2 volts each, the total number of cells or batteries in the series string, including the test cell or battery, is defined by "18 volts/V", rounded up to the nearest whole number, where V is the nominal voltage of one cell or battery. For cells with nominal voltages of 2 volts or greater and batteries containing component cells, each with nominal voltages of 2 volts or greater, the total number of cells or batteries in the series string, including the test cell or battery, is defined by "12 volts/V", rounded up to the nearest whole number, where V is the nominal voltage of one cell or battery. A resistive load is added to the series string of cells or batteries. Where the cell or battery contains no protective devices, the resistive load is such that the average current draw is the same as the maximum discharge current specified by the manufacturer. If the cell or battery contains one or more protective devices, the resistive load should be just above (by not more than 10%) the highest resistive load at which one of those protective devices could activate during the charge test. The circuit is closed, charging the test cell or battery. The test is continued, from the time when the circuit is closed, until the voltage of the series string reaches 10% of its original open circuit voltage or for 24 hours, whichever is longer;

2.2.3.7 internal short circuit: Each cell is deformed until the open circuit voltage drops abruptly or is reduced to at least one third. The deformation is effected by placing the rod between one jaw of the clamping device and the cell and applying force. At the point where the cell voltage drops, the applied force should be removed;

2.2.3.8 low capacity cell: Batteries are discharged under a resistive load. Where protective devices are installed, the resistive load should be just above (by not more than 10%) the highest resistive load at which one of these protective devices could activate during the forced discharge test. Where no protective devices are installed, the resistive load is such that, for a battery assembled with all undischarged or uncycled cells, the average current draw is the same as the maximum discharge rate specified by the manufacturer. The discharge should be terminated when the battery terminal voltage is 10% or less of the original open circuit voltage. Batteries are observed for an additional 24 hours after load removal;

2.2.3.9 forced discharge: A test cell or battery is connected in a series string with undischarged primary cells or batteries or fully charged rechargeable cells or batteries of the same type. For cells with nominal voltages of less than 2 volts and batteries containing component cells with nominal voltages of less than 2 volts each, the total number of cells or batteries in the series string, including the test cell or battery, is defined by "18 volts /V", rounded up to the nearest whole number, where V is the nominal voltage of one cell or battery. For cells with nominal voltages of 2 volts or more and batteries

containing component cells with nominal voltages of 2 volts or more, the total number of cells or batteries in the series string, including the test cell or battery, is defined by "12 volts/V", rounded up to the nearest whole number. A resistive load is added to the series string of cells or batteries. Where the cell or battery contains no protective devices, the resistive load is such that the average current draw is the same as the maximum discharge current specified by the manufacturer. Where protective devices are installed, the resistive load should be just above (by not more than 10%) the highest resistive load at which one of these protective devices could activate on the forced discharge test. The circuit is closed, discharging the test cell or battery. The test is continued, from the time the circuit is closed, until the voltage of the series string reaches 10% of its original open circuit voltage or 24 hours, whichever is longer.

2.2.4 Unless indicated otherwise the criteria given in 2.4 should be used for evaluating each test.

2.3 TEST SERIES

2.3.1 Test Series 1: Altitude simulation, extreme temperature and short circuit

2.3.1.1 introduction: This altitude simulation, extreme temperature exposure and short circuit test is designed to determine the ability of primary and rechargeable lithium cells and batteries to withstand exposure to low pressure, high and low temperatures and external short circuits;

2.3.1.2 apparatus and materials: The following apparatus is required for this test: a balance, a vacuum chamber, an electric oven, a freezer, a conductor with a total resistance of not more than 0.05 ohms, a thermocouple and a recording millivoltmeter;

2.3.1.3 number and condition of cells and batteries to be tested:

Ten primary cells should be tested in both undischarged and fully discharged states.

Four primary batteries should be tested in both undischarged and fully discharged states.

Ten rechargeable cells should be tested, at first cycle, in both fully charged and fully discharged states.

Four rechargeable batteries should be tested, at first cycle, in both fully charged and fully discharged states.

Ten rechargeable cells should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in both fully charged and fully discharged states.

Four rechargeable batteries should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in both fully charged and fully discharged states;

2.3.1.4 Each cell and battery is subjected in sequence to the test procedures described in 2.2.3.1, 2.2.3.2 and 2.2.3.3.

2.3.2 Test Series 2: Vibration, shock and short circuit

2.3.2.1 introduction: This vibration, shock and short circuit test is designed to determine the ability of primary and rechargeable lithium cells and batteries to withstand vibration, shock and external short circuits;

2.3.2.2 apparatus and materials: The following apparatus is required for this test: a vibration machine, a shock test apparatus, a conductor with a total resistance of not more than 0.05 ohms, a thermocouple and a recording millivoltmeter;

2.3.2.3 number and condition of cells and batteries to be tested:

Ten primary cells should be tested in both undischarged and fully discharged states.

Four primary batteries should be tested in both undischarged and fully discharged states.

Ten rechargeable cells should be tested, at first cycle, in both fully charged and fully discharged states.

Four rechargeable batteries should be tested, at first cycle, in both fully charged and fully discharged states.

Ten rechargeable cells should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in both fully charged and fully discharged states.

Four rechargeable batteries should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in both fully charged and fully discharged states;

2.3.2.4 Each cell and battery is subjected in sequence to the test procedures described in 2.2.3.4, 2.2.3.5 and 2.2.3.3.

2.3.3. Test Series 3: Vibration, shock, and charge

2.3.3.1 introduction: A vibration, shock, and charge test is designed to determine the ability of primary and rechargeable lithium cells and batteries to withstand vibration, shock and charging. This test is applicable to all batteries with nominal voltages up to the limits indicated in 2.3.3.3.2 and 2.3.3.3.3 and to all cells;

2.3.3.2 apparatus and materials: The following apparatus is required for this test: a vibration machine, a shock test apparatus, a resistor and a voltmeter;

2.3.3.3 number and condition of cells and batteries to be tested:

2.3.3.3.1 Cells:

Ten primary cells should be tested in the undischarged state.

Ten rechargeable cells should be tested, at first cycle, in the fully charged state.

Ten rechargeable cells should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully charged state;

2.3.3.3.2 Batteries containing component cells with a nominal voltage of less than 2 volts per component cell:

Four primary batteries with a nominal voltage of up to 6 volts should be tested in the undischarged state.

Four rechargeable batteries with a nominal voltage of up to 6 volts should be tested, at first cylce, in the fully charged state.

Four rechargeable batteries with a nominal voltage of up to 6 volts should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully charged state;

2.3.3.3.3 Batteries containing component cells with a nominal voltage of 2 volts or greater per component cell:

Four primary batteries with a nominal voltage of up to 4 volts should be tested in the undischarged state.

Four rechargeable batteries with a nominal voltage of up to 4 volts should be tested, at first cycle, in the fully charged state.

Four rechargeable batteries with a nominal voltage of up to 4 volts should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully charged state.

2.3.3.4 Each cell and battery is subjected in sequence to the test procedures described in 2.2.3.4, 2.2.3.5 and 2.2.3.6.

2.3.4 Test Series 4: Internal short circuit

2.3.4.1 introduction: This internal short circuit test is designed to determine the effects of an internal short circuit in primary and rechargeable lithium cells and component cells;

2.3.4.2 apparatus and materials: The following apparatus is required for this test: a clamping device (vice, hydraulic ram, etc.) with insulated clamping plates, a 6 mm (diameter) rod with a hard insulating surface and a voltmeter;

2.3.4.3 number and condition of cells and batteries to be tested:

This test should be performed on single cells only. In the case of batteries, component cells of the same type as those included in the battery should be used.

Ten primary cells should be tested in the undischarged state.

Ten component cells from primary batteries should be tested in the undischarged state.

Ten rechargeable cells should be tested, at first cycle, in the fully charged state.

Ten component cells from rechargeable batteries should be tested, at first cycle, in the fully charged state;

2.3.4.4 Each cell is subjected to the test procedures described in 2.2.3.7.

2.3.5 Test Series 5: Vibration, shock and low capacity cell

2.3.5.1 introduction: This vibration, shock and low capacity cell test is designed to determine the ability of primary lithium batteries, with one fully discharged cell in each series string, or rechargeable lithium batteries, with one cell cycled to 60% of its rated capacity in each series string, to withstand vibration, shock and forced deep discharge;

2.3.5.2 apparatus and material.: The folowing apparatus is required for this test: a vibration machine, a shock test apparatus, a resistor and a voltmeter;

2.3.5.3 number and condition of cells and batteries to be tested:

Primary batteries should be constructed with undischarged cells except for one in each series string which is fully discharged. Four batteries are tested in the undischarged state.

Rechargeable batteries should be constructed with uncycled cells except for one in each series string which is cycled until the capacity is reduced to 60% of the rated capacity. Four batteries are tested at first cycle in the fully charged state;

2.3.5.4 Each battery is subjected in sequence to the test procedures described in 2.2.3.4, 2.2.3.5 and 2.2.3.8.

2.3.6 Test Series 6: Forced discharge

2.3.6.1 introduction: This forced discharge test is designed to determine the ability of primary and rechargeable lithium cells and batteries to withstand forced deep discharge. This test is applicable to all batteries with nominal voltages up to the limits specified in 2.3.6.3.2 and 2.3.6.3.3, and to all cells;

2.3.6.2 apparatus and materials: The following apparatus is required for this test: a resistor and voltmeter;

2.3.6.3 number and condition of cells and batteries to be tested:

2.3.6.3.1 Cells:

Ten primary cells should be tested in the fully discharged state.

Ten rechargeable cells should be tested, at first cycle, in the fully discharged state.

Ten rechargeable cells should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully discharged state;

2.3.6.3.2 Batteries containing component cells with a nominal voltage of less than 2 volts per component cell.

Four primary batteries with a nominal voltage of up to 9 volts should be tested in the fully discharged state.

Four rechargeable batteries with a nominal voltage of up to 9 volts should be tested, at first cycle, in the fully discharged state.

Four rechargeable batteries with a nominal voltage of up to 9 volts should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully discharged state;

2.3.6.3.3 Batteries containing component cells with a nominal voltage of 2 volts or greater per component cell:

Four primary batteries with a nominal voltage of up to 6 volts should be tested in the fully discharged state.

Four rechargeable batteries with a nominal voltage of up to 6 volts should be tested, at first cycle, in the fully discharged state.

Four rechargeable batteries with a nominal voltage of up to 6 volts should be tested, after cycling to reduce the capacity to 60% of the rated capacity, in the fully discharged state.

2.3.6.4 Each cell and battery is subjected to the test procedure described in 2.2.3.9.

2.4 TEST CRITERIA AND METHOD OF ASSESSING THE RESULTS

2.4.1 A lithium cell or battery is of the type proved to be non-dangerous if:

(a) no disassembly or fire occurs;

(b) in the case of Test Series 1, 2 and 5 unless the effluent is not toxic, flammable or corrosive:

(i) no venting or leakage is evident by visual observation; and

(ii) no venting or leakage occurs which results in a loss of mass exceeding that shown below; and

(c) in the case of Test Series 3 and 6, unless the effluent is not toxic or corrosive:

(i) no venting or leakage is evident by visual observation; and

(ii) no venting or leakage occurs which results in a loss of mass exceeding that shown below.

Mass of Cell or Battery	Maximum Mass Loss (%)
not more than 1 g	0.5
more than 1 g but not more than 5 g	0.2
more than 5 g	0.1

2.4.2 A lithium cell or battery is included in Class 9 if:

(a) no disassembly or fire occurs; and

(b) where the effluent is toxic, flammable or corrosive, a venting or leakage occurs on Test Series 1, 2 or 5:

(i) which is evident by visual observation; or

(ii) which results in a loss of mass exceeding that shown in the table in 2.4.1; or

(c) where the effluent is toxic or corrosive, a venting or leakage occurs on Test Series 3 or 6:

(i) which is evident by visual observation; or

(ii) which results in a loss of mass exceeding that shown in 2.4.1.

2.4.3 Where a lithium cell or battery disassembles or produces a fire during the testing procedure, it may only be transported with special authorization granted by the competent authority."

CONSEQUENTIAL AMENDMENTS

Foreword of the publication (ST/SG/AC.10/11/Rev.1)

Amend the text relating to Part IV to read as follows:

"Part IV: Tests and Criteria for the classification of miscellaneous dangerous goods.

At its fifteenth session, the Committee adopted the "Trough" test for the propagation of exothermic decomposition in fertilizers containing nitrates which are considered for assignment to Class 9; the test and criterion are reproduced in Section 1, "Test for ammonium nitrate fertilizers of Class 9".

At its seventeenth session, the Committee adopted a new Section for the procedures to be followed for the classification of lithium cells and batteries (Section 2: Tests methods for lithium cells and batteries)."

Preface of Part IV

Amend to read:

"This part of the Manual is a compilation of the various tests and criteria for the classification of miscellaneous dangerous goods.

Section 1 gives the description of the "trough test". This test is recommended for the determination of the hazard of self-sustaining decomposition. On the basis of this test fertilizers are classified as a substance of Class 9 or are considered not to present the hazard of self-sustaining decomposition.

Section 2 contains tests and criteria for the classification of lithium cells and batteries (UN 3090 and UN 3091). These batteries should be classified according to special provisions 188 and 230 of Chapter 3 of the Recommendations on the Transport of Dangerous Goods, and when applicable, according to this Section 2."